ETRX35x-LRS ZIGBEE MODULES

PRODUCT MANUAL

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Image not shown actual size; enlarged to show detail.

The Telegesis ETRX351-LRS and ETRX357-LRS modules are low power 2.4GHz ZigBee modules with an added frontend module (SiGe SE2432L) containing both PA and LNA for highest possible link budget.

Based on the latest Ember EM351 and EM357 single chip ZigBee solution the new long range modules are footprint compatible with the ETRX351 and ETRX357, thus representing a drop-in replacement for all applications where a high link budget is required.

The module's unique AT-style command line interface allows designers to quickly integrate ZigBee technology without complex software engineering. For custom application development the ETRX35x series integrates with ease into Ember's InSight development environment.

Module Features

- Small form factor, SMT module 25mm x 19mm
- Side Castellations for easy soldering and inspection
- 2 antenna options: Integrated chip antenna or U.FL coaxial connector
- Industry's first ARM® Cortex-M3 based family of ZigBee modules
- Industry standard JTAG Programming and real time network level debugging via the Ember InSight Port
- 192kB (ETRX357-LRS) and 128kB (ETRX351-LRS) flash and 12kbytes of RAM
- Lowest Deep Sleep Current of sub 1µA and multiple sleep modes
- Ultra Wide supply voltage range (2.1 to 3.6V)
- 32.768kHz watch crystal can be added externally
- Module ships with standard Telegesis AT-style command interface based on the ZigBee PRO feature set
- Can act as an End Device, Router or Coordinator
- 22 general-purpose I/O lines including analogue inputs
- Firmware upgrades via serial port or over the air (password protected)
- Hardware supported encryption (AES-128)
- CE and FCC compliance, FCC modular approval
- Operating temperature range: -40˚C to +85˚C
- Standard version without LNA and PA available in the same form factor

Radio Features

- Based on the Ember EM351 and EM357 single chip ZigBee / IEEE802.15.4 solutions
- 2.4GHz ISM Band
- 250kbit/s over the air data rate – NB: actual usable data throughput with ZigBee is about 20kbps
- 15 channels (IEEE802.15.4 Channel 11 to 25)
- SiGe SE2432L integrated PA and LNA
- +20dBm output power (adjustable down to -41dBm)
- High sensitivity of -106dBm typ. @ 1% packet error rate
- RX Current: 33mA, TX Current: approx 140mA at 20dBm

Suggested Applications

- AMR – ZigBee Smart Energy applications
- Wireless Alarms and Security
- Home/Building Automation
- Wireless Sensor Networks
- M2M Industrial Controls
- Lighting and ventilation control
- Remote monitoring
- Environmental monitoring and control

Development Kit

- New Development kit containing everything required to set up a mesh network quickly and evaluate range and performance of the ETRX35x and its long range version.
- AT-style software interface command dictionary can be modified for high volume customers.
- Custom software development available upon request.

Example AT-Style Commands

AT+BCAST	Send a Broadcast
AT+UCAST:<address>	Send a Unicast
AT+EN	Establish PAN network
AT+JN	Join PAN

At power-up the last configuration is loaded from non-volatile S-Registers, which can eliminate the need for an additional host controller.

1 Introduction

This document describes the Telegesis ETRX351-LRS and ETRX357-LRS ZigBee long range modules which have been designed to be easily integrated into another device and to provide a fast, simple and low cost wireless mesh networking interface.

The Telegesis ETRX3 series modules are based on the Ember ZigBee platform consisting of the single chip EM351 or EM357 combined with the ZigBee PRO compliant EmberZNet meshing stack. Integration into a wide range of applications is made easy using a simple AT style command interface and advanced hardware design.

The configurable functionality of the Telegesis AT Commandset often allows the ETRX3 series ZigBee modules to be used without an additional host microcontroller saving even more integration time and costs. In addition to the Telegesis AT Commandset, the ETRX351-LRS and ETRX357-LRS modules can be used with custom-built firmware and they represent an ideal platform for custom firmware development in conjunction with the Ember development kits. The ETRX3 series shares the same R3xx Telegesis firmware as the ETRX2 and the two devices can be used in the same network.

No RF experience or expertise is required to add this powerful wireless networking capability to your products. The ETRX351-LRS and ETRX357-LRS offer fast integration opportunities and the shortest possible time to market for your product.

1.1 Hardware Description

The main building blocks of the ETRX351-LRS and ETRX357-LRS are the single chip EM351 and EM357 from Ember, a SiGe SE2432L frontend module combining a Power Amplifier with a Low Noise Amplifier, a 24MHz reference crystal and RF front-end circuitry optimized for best RF performance. The modules are available with on-board antenna or alternatively a U.FL connector for attaching external antennae. Modules with the U.FL connector are identified by the “HR” suffix.

The LNA and RF power amplifier of the LRS devices improve the output power by 12dB and the sensitivity by 5dB which will increase the range by approximately 700% relative to the standard devices (where local regulations permit the use of the maximum output power).

The integrated antenna is an Antenova Rufa, and details of the radiation pattern etc are available from the Antenova website 0.

Module	Chip	Flash	RAM
ETRX351-LRS	EM351	128kB	12kB
ETRX351HR-LRS	EM351	128kB	12kB
ETRX357-LRS	EM357	192kB	12kB
ETRX357HR-LRS	EM357	192kB	12kB

Table 1: Memories

The ETRX351-LRS and ETRX357-LRS are used for ZigBee (www.zigbee.org) applications. If you wish to create your own custom firmware, and not use the pre-loaded Telegesis AT-Command interface, you will need the InSight toolchain, consisting of InSight Desktop™ together with a comprehensive integrated development environment (IDE) and C-language compiler toolchain from Ember. The Ember development environment is not suitable for an 802.15.4-only application that does not use the ZigBee layer.

2 Product Approvals

The ETRX351-LRS and ETRX357-LRS as well as the ETRX351HR-LRS and ETRX357HR-LRS have been designed to meet all national regulations for world-wide use. In particular the following certifications have been obtained:

2.1 FCC Approvals

The Telegesis ETRX351-LRS and ETRX357-LRS with integrated Antenna as well as the ETRX351HR-LRS and the ETRX357HR-LRS including the antennae listed in Table 2 comply with FCC CFR Part 15 (USA). The devices meet the requirements for modular transmitter approval as detailed in the FCC public notice DA00.1407.transmitter.

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

FCC ID: S4GEM35XB

This module complies with the USA SAR requirements and is not intended to be operated within 20cm of the body. The following statement must be included as a CAUTION statement in manuals for OEM products to alert users on FCC RF exposure compliance

"WARNING: To satisfy FCC RF exposure requirements for mobile transmitting devices, a separation distance of 20cm or more should be maintained between the antenna of this device and persons during operation. To ensure compliance, operations at closer distances than this are not recommended."

Item	Part No.	Manufacturer	Type	Impedance	Gain
1	BKR2400	Embedded Antenna Design Ltd.	½ Wave	50Ω	2 dBi
2	BT-Stubby (Straight)	Embedded Antenna Design Ltd.	¼ Wave	50Ω	0 dBi
3	BT-Stubby (right-angle)	Embedded Antenna Design Ltd.	¼ Wave	50Ω	0 dBi
4	Rufa (on board)	Antenova	Chip	50Ω	2.1dBi (peak)

Table 2. Approved Antennae

An end user deploying an ETRX35x-LRS or an ETRX35xHR-LRS module together with an antenna as listed in Table 2 is not required to obtain a new authorization for the module – BUT this does not preclude the possibility that some other form of authorization or testing may be required for the end product depending upon local territorial regulations.

The FCC requires the user to be notified that any changes or modifications made to this device that are not expressly approved by Telegesis (UK) Ltd. may void the user's authority to operate the equipment.

When using the ETRX351HR-LRS and ETRX357HR-LRS with approved antennae, it is required to prevent end-users from replacing them with non-approved ones. FCC Labelling Requirements

When integrating the ETRX351-LRS, ETRX357-LRS, ETRX351HR-LRS and ETRX357HR-LRS into a product if must be ensured that the FCC labelling requirements are met. This includes a clearly visible label on the outside of the finished product specifying the Telegesis FCC identifier (**FCC ID: S4GEM35XB**) as well as the notice above. This exterior label can use wording such as **"Contains Transmitter Module FCC ID: S4GEM35XB"** or **"Contains FCC ID: S4GEM35XB"** although any similar wording that expresses the same meaning may be used.

2.2 IC (Industry Canada) Approvals

The Telegesis ETRX351-LRS, ETRX357-LRS, ETRX351HR-LRS and ETRX357HR-LRS modules have been approved by Industry Canada to operate with the antenna types listed in Table 2 with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

IC-ID: 8735A-EM35XB

- This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

- Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication.

- To comply with Industry Canada RF radiation exposure limits for general population, the antenna(s) used for this transmitter must be installed such that a minimum separation distance of 20cm is maintained between the radiator (antenna) and all persons at all times and must not be co-located or operating in conjunction with any other antenna or transmitter.

- This device has been designed to operate with the antennas listed in Table 2, and having a maximum gain of 2.0 dBi. Antennas not included in this list or having a gain greater than 2.0 dBi are strictly prohibited for use with this device. The required antenna impedance is 50 ohms.

The labelling requirements for Industry Canada are similar to those of the FCC. Again a clearly visible label must be placed on the outside of the finished product stating something like "Contains Transmitter Module, IC: 8735A-EM35XB", although any similar wording that expresses the same meaning may be used.

The integrator is responsible for final product compliance with IC ICES-003 and FCC Part 15, Sub. B – Unintentional Radiators.

2.3 European Certification

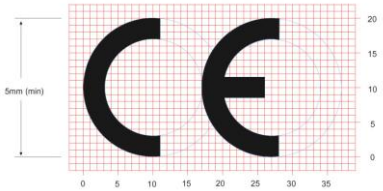
The ETRX351-LRS, ETRX357-LRS, ETRX351HR-LRS and ETRX357HR-LRS modules are certified at a maximum power level of 21.15mW e.i.r.p. (13.2dBm) to the following standards:

- Radio: EN 300 328 v1.7.1 (10/2006)
- EMC: EN 301 489-17 v2.1.1 (09/2008)
- Safety: EN 60950-1:2006

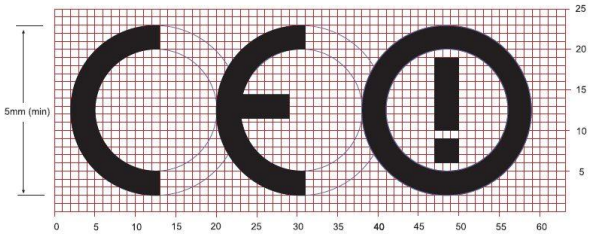
The tests have been conducted with the antennae listed in Table 2.

If the ETRX351-LRS, ETRX357-LRS, ETRX351HR-LRS or ETRX357HR-LRS module is incorporated into an OEM product, the OEM product manufacturer must ensure compliance of the final product to the European Harmonised EMC, and low voltage/safety standards. A Declaration of Conformity must be issued for each of these standards and kept on file as described in the R&TTE Directive. The final product must not exceed the specified power ratings, antenna specifications and installation requirements as specified in this user manual. If any of these specifications are exceeded in the final product then a submission must be made to a notified body for compliance testing to all of the required standards.

The 'CE' marking must be applied to a visible location on any OEM product. For more information please refer to http://ec.europa.eu/enterprise/faq/ce-mark.htm. Customers assume full responsibility for learning and meeting the required guidelines for each country in their distribution market.



Important Note: In Europe the regulations for the 2.4GHz frequency band are only harmonized for devices with an e.i.r.p. of less than 10mW (10dBm). In the case of e.i.r.p. of more than 10mW the manufacturer or his authorised representative established within the community or the person responsible for placing the equipment on the market shall notify the national authority responsible in the relevant Member State for spectrum management of the intention to place such equipment on its national market. This notification shall be given no less than four weeks in advance of the start of placing on the market. . In addition to this equipment must also be marked with a warning symbol to draw the user's attention to the fact that it might not be legal to use the equipment in every member state.



Because of this Telegesis recommends that the user limits the output power to 10mW (10dBm) for Europe to avoid having to deal with the local authorities for spectrum management of each relevant member state.

2.4 ICASA Approvals

The ETRX351-LRS, ETRX357-LRS, ETRX351HR-LRS and ETRX357HR-LRS have been certified to be used in South Africa.

2.5 Australia and New Zealand (C-Tick)

The ETRX351-LRS, ETRX357-LRS, ETRX351HR-LRS and ETRX357HR-LRS have been certified to be used in Australia and New Zealand.

In order to have a C-Tick mark on an end product integrating an ETRX3xx device, a company must comply with a or b below.

a). have a company presence in Australia.

b). have a company/distributor/agent in Australia that will sponsor the importing of the end product.

2.6 Brazil

The ETRX357-LRS and ETRX357HR-LRS have been certified to be used in Brazil.

Modelo: ETRX357-LRS
ANATEL
1501-11-7014
(01)07898941575069
" Este equipamento opera em caráter secundário, isto é, não tem direito a proteção contra interferência prejudicial, mesmo de estações do mesmo tipo, e não pode causar interferência a sistemas operando em caráter primário."
Modelo: ETRX357HR-LRS
ANATEL
1501-11-7014
(01)07898941575076
" Este equipamento opera em caráter secundário, isto é, não tem direito a proteção contra interferência prejudicial, mesmo de estações do mesmo tipo, e não pode causar interferência a sistemas operando em caráter primário."

2.7 Declarations of Conformity

Telegesis (UK) Ltd has issued Declarations of Conformity for all ETRX3 series ZigBee RF Modules, which cover Radio Emissions, EMC and Safety. These documents will be available from our website or on request

2.8 IEEE 802.15.4

IEEE 802.15.4 is a standard for low data rate, wireless networks (raw bit-rate within a radio packet of 250kbps @2.4GHz) which focuses on low cost, low duty cycle, long primary battery life applications as well as mains-powered applications. It is the basis for the open ZigBee Protocol.

2.9 The ZigBee Protocol

The ZigBee Protocol is a set of standards for wireless connectivity for use between any devices over short to medium distances. The specification was originally ratified in December 2004, paving the way for companies to start making low-power networks a reality.

ZigBee uses an IEEE 802.15.4 radio specification running on the 2.4GHz band, plus three additional layers for networking, security and applications. What makes the specification unique is its use of a mesh network architecture which, in bucket chain style, passes data from one node to the next until it lands at its destination. The network is self-healing and adapts its routing as link

quality changes or nodes move. Furthermore, nodes can be defined as End Devices which do not act as routers, but can therefore be put into a low-power sleep state.

The enhanced version of the ZigBee standard (or ZigBee 2006) was released in December 2006, adding new features and improvements to the only global wireless communication standard enabling the development of easily deployable low-cost, low-power, monitoring and control products for homes, commercial buildings and industrial plant monitoring. In 2007 the ZigBee Alliance introduced the PRO feature-set which offers advantages over earlier feature-sets, including

- Truly self healing mesh networking
- Messages can now travel up to 30 hops
- Source-Routing for improved point to multipoint message transmission
- Improved security including Trust-Centre link keys
- New message types and options

The Telegesis AT Command-set, which by default ships on all ETRX3 series products is based on the ZigBee PRO feature-set. For more information on the Telegesis AT Command-set please refer to the separate documentation at www.telegesis.com.

3 Module Pinout

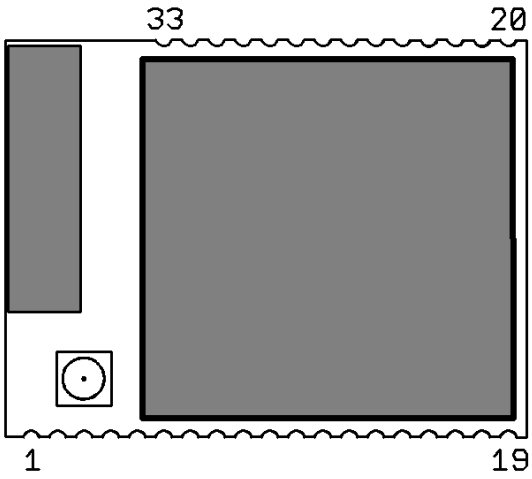


Figure 1. ETRX3 series Module Pinout (top view)

The table below gives details about the pin assignment for direct SMD soldering of the ETRX3 series modules to the application board. For more information on the alternate functions please refer to [2]. Also refer to the Telegesis AT Command-set documentation to understand how the pre-programmed firmware makes use of the individual I/Os.

All GND pads are connected within the module, but for best RF performance all of them should be grounded externally.

ETRX35x pad	Designation	Normal function	Alternate function	EM35x pin	Ember designation
1	GND	GND		GND	
2	TX_ACTIVE{1}	I/O		11	TX_ACTIVE. PC5 of the EM35x is used to control the FEM
3	PC6	I/O		13	OSC32B, nTX_ACTIVE
4	PC7	I/O		14	OSC32A, OSC32_EXT
5	PA7 {4}	I/O		18	TIM1C4
6	PB3 {2}	I/O	CTS	19	SC1nCTS, SC1SCLK, TIM2C3
7	nReset {5}	nReset		12	
8	PB4 {2}	I/O	RTS	20	TIM2C4, SC1nRTS, SC1nSSEL
9	PA0	I/O		21	TIM2C1, SC2MOSI
10	PA1	I/O		22	TIM2C3, SC2SDA, SC2MISO
11	PA2	I/O		24	TIM2C4, SC2SCL, SC2SCLK
12	PA3	I/O		25	SC2nSSEL, TRACECLK, TIM2C2
13	GND	GND		GND	
14	PA4	I/O		26	ADC4, PTI_EN, TRACEDATA
15	PA5 {3}	I/O		27	ADC5, PTI_DATA, nBOOTMODE, TRACEDATA3
16	PA6 {4}	I/O		29	TIM1C3
17	PB1	TXD		30	SC1MISO, SC1MOSI, SC1SDA, SC1TXD, TIM2C1
18	PB2	RXD		31	SC1MISO, SC1MOSI, SC1SCL, SC1RXD, TIM2C2
19	GND	GND		GND	

ETRX35x pad	Designation	Normal function	Alternate function	EM35x pin	Ember designation
20	GND	GND		GND	
21	JTCK	JTCK		32	SWCLK
22	PC2	I/O		33	JTDO, SWO
23	PC3	I/O		34	JTDI
24	PC4	I/O		35	JTMS, SWDIO
25	N/C{1}	N/C		36	PB0 of the EM35x is used to control the FEM
26	PC1	I/O	ADC3	38	ADC3, SWO, TRACEDATA0
27	PC0 {4}	I/O		40	JRST, IRQD, TRACEDATA1
28	PB7 {4}	I/O	ADC2	41	ADC2, IRQC, TIM1C2
29	PB6 {4}	I/O	ADC1	42	ADC1, IRQB, TIM1C1
30	PB5	I/O	ADC0	43	ADC0, TIM2CLK, TIM1MSK
31	GND	GND		GND	
32	Vcc	Vcc		Vcc	
33	GND	GND		GND	

Table 3. Pin Information

Notes:

{1} Pins PB0 and PC5 of the EM357 are used internally to control the front-end module. PB0 is not available to the user.

{2} When using the Telegesis AT Command-set, RTS/CTS handshaking is selectable in firmware. See the AT Command Manual.

{3} If PA5 is driven low at power-up or reset the module will boot up in the bootloader

{4} PA6, PA7, PB6, PB7 and PC0 can drive high current (see section 0)

{5} nRESET is level-sensitive, not edge-sensitive. The module is held in the reset state while nRESET is low

Alternate functions depend on the firmware, but the Telegesis R3xx AT Command-set functions are indicated here for convenience.

Important Note: The ETRX35x series and the ETRX35x-LRS series of modules are footprint compatible, but on the ETRX35x-LRS series pins PB0 and PC5 of the EM357 are used internally to control the front-end module and are not available to the user. PC5 is still available on Pad2, but it is configured as TX_ACTIVE signal and cannot be used as a general purpose GPIO.

4 Hardware Description

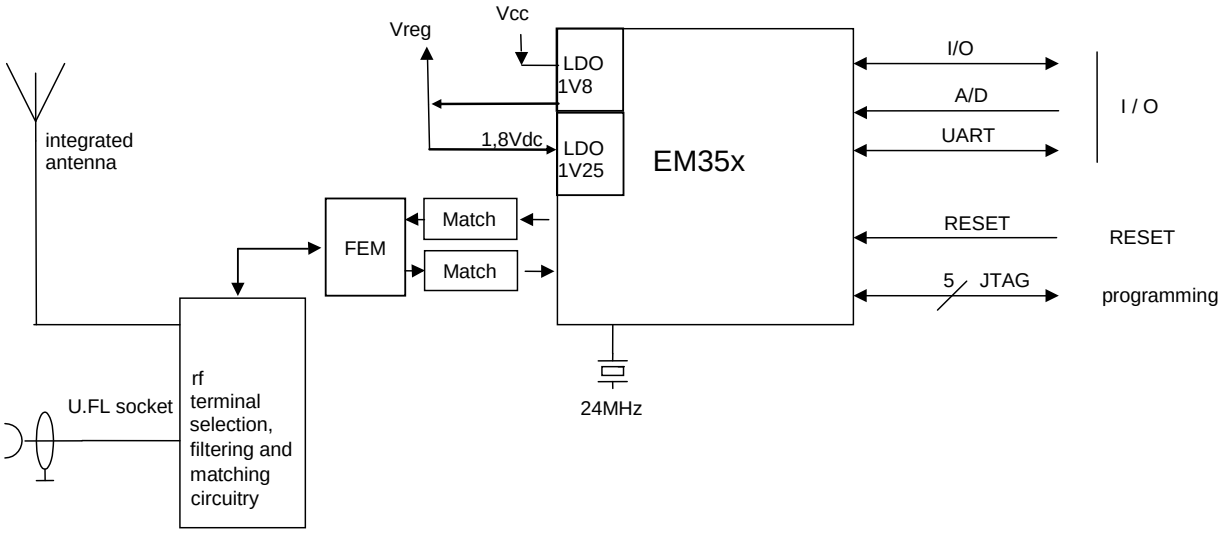


Figure 2. Hardware Diagram

The ETRX351-LRS and ETRX357-LRS are based on the Ember EM351 and EM357 respectively in addition to a frontend module containing a PA, LNA and RF switch in addition to the RF-Frontend. The EM351 and EM357 are fully integrated 2.4GHz ZigBee transceivers with a 32-bit ARM® Cortex M3™ microprocessor, flash and RAM memory, and peripherals.

The industry standard serial wire and JTAG programming and debugging interfaces together with the standard ARM system debug components help to streamline any custom software development.

In addition to this a number of MAC functions are also implemented in hardware to help maintain the strict timing requirements imposed by the ZigBee and IEEE802.15.4 standards.

The new advanced power management features allow faster wakeup from sleep and new power-down modes allow this 3rd generation module to offer a longer battery life than any 2nd generation modules on the market.

The EM35x has fully integrated voltage regulators for both required 1.8V and 1.25V supply voltages. The voltages are monitored (brown-out detection) and the built in power-on-reset circuit eliminates the need for any external monitoring circuitry. A 32.768kHz watch crystal can be connected externally to pads 3 and 4 in case more accurate timing is required.

4.1 Hardware Interface

All GPIO pins of the EM351 or EM357 except PB0 and PC5 are accessible on the module's pads. Whether signals are used as general purpose I/Os, or assigned to a peripheral function like ADC is set by the firmware. When using the Telegesis AT Command-set please refer to the AT Command-set manual for this information and when developing custom firmware please refer to the EM35x datasheet.

5 Firmware Description

The modules will be pre-loaded with a standalone bootloader by Ember, which supports over-the-air bootloading as well as serial bootloading of new firmware.

In order to enter the standalone bootloader using a hardware trigger pull PA5 to ground and power-cycle or reset the module. To avoid entering the standalone bootloader unintentionally make sure not to pull this pin down during boot-up unless the resistance to ground is >10kΩ. A pull-up is not required).

In addition to the standalone bootloader the modules also contain the current release of the Telegesis AT-style command interface as described in the Telegesis AT command dictionary and the Telegesis user guide. Check www.telegesis.com for updates. Each module comes with a unique 64-bit 802.15.4 identifier which is stored in non-volatile memory. The commands and responses pass through the serial port of the ETRX35x-LRS as ASCII text, so a simple terminal application will usually suffice. Telegesis Terminal is provided as a development tool, but it is not an essential feature.

The pre-loaded AT-style command interface firmware is based on the latest EmberZNet meshing stack which implements routers/coordinators as well as (sleepy) end devices. [End devices have no routing responsibility and therefore are allowed to go to sleep, whilst still being able to send and receive messages via a parent router. In addition to a classical (sleepy) end device the module firmware also supports mobile (sleepy) end devices capable of changing their parent quickly whenever they change their position within the network.]

A router is typically a mains powered device whilst a sleepy end device (SED) can be battery powered.

The module is also able to act as a PAN coordinator and Trust Centre through external host control. The AT style command line supplies all the tools required to set up and manage a ZigBee network by allowing easy access to the low-level functionality of the stack.

The Telegesis firmware uses the meshing and self healing EmberZNet PRO stack to overcome many of the limitations of the tree network topology of the ZigBee 2006 stack by using the ZigBee PRO feature-set.

The Telegesis firmware also allows low-level access to physical parameters such as radio channel and power level. Parameters that define the functionality of the ETRX35x-LRS module and also allow standalone functionality are saved in non-volatile memory organised in so-called S-Registers. The SPI and I2C buses are not supported by the current firmware release, but can be used with custom firmware.

5.1 Token Settings

The ETRX3 Series Modules' tokens will be pre-programmed with the settings shown in the table below.

Token	Description	TG Default
MFG_CIB_OBS	Option Bytes	<not written>
MFG_CUSTOM_VERSION	Optional Version Number	<not written>
MFG_CUSTOM_EUI_64	Custom EUI	<not written>
MFG_STRING	Device Specific String	TELEGESIS
MFG_BOARD_NAME	Hardware Identifier	<Order Code>
MFG_MANUF_ID	Manufacturer ID	0x1010
MFG_PHY_CONFIG	Default Power Settings	0XFFFD
MFG_BOOTLOAD_AES_KEY	Bootloader Key	<not written>
MFG_EZSP_STORAGE	EZSP related	<not written>
MFG_CBKE_DATA	SE Security	<not written>
MFG_INSTALLATION_CODE	SE Installation	<not written>
MFG_OSC24M_BIAS_TRIM	Crystal Bias	<not written>

Table 4. Manufacturing tokens

5.2 Custom Firmware

For high volume customers the firmware can be customised on request. Customers can use the ETRX35x-LRS module as hardware only and develop application specific firmware based on the EmberZNet stack. In order to develop custom firmware the Ember Insight tool-chain is required.

When writing firmware for the ETRX357-LRS it is important to ensure that pins PB0 and PC5 are correctly configured in order that the RF front-end module can operate correctly. An application note " Writing customised firmware for the ETRX35x-LRS" can be downloaded from the Telegesis website.

5.3 Boost Mode vs. Normal Mode

The Ember EM35x chips support a "boost mode" power setting next to the "normal mode" power setting. The "boost mode" setting increases the sensitivity and output power of the radio transceiver, however with the LRS variants enabling boost mode has no positive effect on neither the output power nor the sensitivity and therefore it is recommended to not use boost mode on this platform. The Telegesis AT Command-set firmware automatically disables boost mode on LRS series modules.

Section 0 lists the requirements for power settings for use of the LRS family in different countries.

5.4 Software Interface

Using the default firmware the ETRX35x-LR is controlled using a simple AT-style command interface and (mostly) non-volatile S-Registers. In order to get a full listing of all the available AT-Commands, please refer to the AT command dictionary document which corresponds to the firmware revision you intend to use.

In addition to the command dictionary there are user guides explaining the features of the firmware in more detail. If you need to find out which firmware resides on your module simply type "**ATI**" followed by a carriage return and you will be prompted with the module's manufacturing information.

The Development Kit manual describes how to upgrade the firmware either via a serial link or over the air.

6 Absolute Maximum Ratings

Supply: **3.6V**
Inputs: **-0.3V to Vcc + 0.3V**
Operating temperature: **-40 to 85°C**

No.	Item	Symbol	Absolute Maximum Ratings	Unit
1	Supply voltage	V_{CC}	-0.3 to +3.6	Vdc
2	Voltage on any I/O[11:0] , SIF_CLK, SIF_MISO, SIF_MOSI, SIF_LOADB, RESET	V_{in}	-0.3 to V_{CC} +0.3	Vdc
3	Voltage on any Pad pin (PA4, PA5, PB5, PB6, PB7, PC1), when used as an input to the general purpose ADC with the low voltage range selected	V_{in}	-0.3 to +2.0	Vdc
4	Storage temperature range	T_{stg}	-40 to +105	°C
5	Operating temperature range	T_{op}	-40 to +85	°C
6	Input RF level	P_{max}	15	dBm
7	ESD on any pin {1} except the RF port according to Human Body Model (HBM) circuit description	V_{THHBM}	±1	kV
8	ESD on RF Port	V_{THHBM}	500	V
9	Reflow temperature	T_{Death}	Please refer to chapter 0	°C

Table 5. Absolute Maximum Ratings

Note:

{1} Input must be current limited to the value specified.

The absolute maximum ratings given above should under no circumstances be violated. Exceeding one or more of the limiting values may cause permanent damage to the device.

Caution! ESD sensitive device. Precautions should be used when handling the device in order to prevent permanent damage.

7 Recommended Operating Conditions

No.	Item	Condition / Remark	Symbol	Value			Unit
				Min	Typ	Max	
1	Supply voltage		V_{CC}	2.1	3.0	3.6	Vdc
2	RF Input Frequency		f_C	2405		2480	MHz
3	RF Input Power		p_{IN}			0	dBm
4	Operating temperature range		T_{op}	-40		+85	°C

Table 6. Recommended Operating Conditions

8 DC Electrical Characteristics

V_{CC} = 3.0V, T_{AMB} = 25°C, NORMAL MODE unless otherwise stated

No.	Item	Condition / Remark	Symbol	Value			Unit
				Min	Typ	Max	
1	Module supply voltage		V_{CC}	2.1	3.0	3.6	Vdc
2	Quiescent current, internal RC oscillator disabled		I_{SLEEP}		1		µA
3	Quiescent current, internal RC oscillator enabled		I_{SLEEP}		1.2		µA
4	Quiescent current, including 32.768kHz oscillator		I_{SLEEP}		1.5		µA
5	Transmit current consumption	at +20dBm module output power	I_{TXVCC}		140		mA
7	Transmit current consumption	at min. module output power	I_{TXVCC}		52		mA
8	Receive current consumption	Total, 12MHz clock speed	I_{RX}		30		mA
9	Receive current consumption	Total, 24MHz clock speed	I_{RX}		31.5		mA
12	MCU, RAM and flash, FEM, radio off	12MHz clock speed	I_{MCU}		7		mA
13	MCU, RAM and flash, FEM, radio off	24MHz clock speed	I_{MCU}		8		mA
14	Serial Controller	Max data rate	I_{SC}		0.2		mA
15	Timer	Max clock rate	I_{TMR}		0.25		mA
16	ADC	Max sample rate	I_{ADC}		1.1		mA
17	Wake time from deep sleep	From wakeup event to 1st instruction			100		µs
18	Shutdown time	From last instruction into deep sleep			5		µs

Table 7. DC Electrical Characteristics

Please Note: The average current consumption during operation is dependent on the firmware and the network load, therefore these figures are given in the command dictionary of the respective firmware.

9 Digital I/O Specifications

The digital I/Os of the ETRX35x module have the ratings shown below.

V_{CC} = 3.0V, T_{AMB} = 25°C, NORMAL MODE unless otherwise stated

No.	Item	Condition / Remark	Symbol	Value			Unit
				Min	Typ	Max	
1	Low Schmitt switching threshold	Schmitt input threshold going from high to low	V_{SWIL}	0.42 x V_{CC}		0.5 x V_{CC}	Vdc
2	High Schmitt switching threshold	Schmitt input threshold going from low to high	V_{SWIH}	0.62 x V_{CC}		0.8 x V_{CC}	MHz
3	Input current for logic 0		I_{IL}			-0.5	µA
4	Input current for logic 1		I_{IH}			0.5	µA
5	Input Pull-up resistor value		R_{IPU}	24	29	34	kΩ
6	Input Pull-down resistor value		R_{IPD}	24	29	34	kΩ
7	Output voltage for logic 0	I_{OL} = 4mA (8mA) for standard (high current) pads	V_{OL}	0		0.18 x V_{CC}	V
8	Output voltage for logic 1	I_{OH} = 4mA (8mA)for standard (high current) pads	V_{OH}	0.82 x V_{CC}		V_{CC}	V
9	Output Source Current	Standard current pad	I_{OHS}			4	mA
10	Output Sink current	Standard current pad	I_{OLS}			4	mA
11	Output Source Current	High current pad (1)	I_{OHH}			8	mA
12	Output Sink current	High current pad (1)	I_{OLH}			8	mA
13	Total output current		I_{OH} + I_{OL}			40	mA

Table 8. Recommended Operating Conditions

Notes

1) High current pads are PA6, PA7, PB6, PB7, PC0

10 A/D Converter Characteristics

The ADC is a first-order sigma-delta converter. For additional information on the ADC please refer to section 10 of the EM35x datasheet.

No.	Item	
1	A/D resolution	Up to 14 bits
2	A/D sample time for 7-bit conversion	5.33µs
3	A/D sample time for 14-bit conversion	682µs
4	Reference Voltage	1.2V

Table 9. A/D Converter Characteristics

11 AC Electrical Characteristics

V_{CC} = 3.0V, T_{AMB} = 25°C, NORMAL MODE measured at 50Ω terminal load connected to the U.FL socket

No.	Receiver	Value			Unit
		Min	Typ	Max	
1	Frequency range	2400		2500	MHz
2	Sensitivity for 1% Packet Error Rate (PER)	-107	-106	-100	dBm
4	Saturation (maximum input level for correct operation)	-3	2		dBm
5	High-Side Adjacent Channel Rejection (1% PER and desired signal –82dBm acc. to [1])		41		dB
6	Low-Side Adjacent Channel Rejection (1% PER and desired signal –82dBm acc. to [1])		40		dB
7	2nd High-Side Adjacent Channel Rejection (1% PER and desired signal –82dBm acc. to [1])		54		dB
8	2nd Low-Side Adjacent Channel Rejection (1% PER and desired signal –82dBm acc. to [1])		52		dB
9	Channel Rejection for all other channels (1% PER and desired signal –82dBm acc. to [1])		tbd		dB
10	802.11g rejection centred at +12MHz or –13MHz (1% PER and desired signal –82dBm acc. to [1])		tbd		dB
11	Co-channel rejection (1% PER and desired signal –82dBm acc. to [1])		tbd		dBc
12	Relative frequency error (2x40ppm required by [1])	-120		120	ppm
13	Relative timing error (2x40ppm required by [1])	-120		120	ppm
14	Linear RSSI range	35			dB
15	Output power at highest power setting NORMAL MODE BOOST MODE	 20 20	 21 21	 21.5 21.5	dBm
16	Output power at lowest power setting			-40	dBm
17	Error vector magnitude as per IEEE802.15.4		7	15	%
18	Carrier frequency error	-40		40	ppm

Table 10. AC Electrical Characteristics

Please Note: For the relationship between EM35x power settings and module output power please relate to chapter 0 of this document. When developing custom firmware the output power settings described in this document relate directly to the EM35x power settings accessible via the Ember stack API. When using the Telegesis AT Command-set firmware the settings mentioned in

this document directly relate to the settings in the S-Register S01 which is used for setting the output power.

No.	Synthesiser Characteristics	Limit			Unit
		Min	Typ	Max	
22	Frequency range	2400		2500	MHz
23	Frequency resolution		11.7		kHz
24	Lock time from off state, with correct VCO DAC settings			100	µs
25	Relock time, channel change or Rx/Tx turnaround			100	µs
26	Phase noise at 100kHz offset		-71dBc/Hz		
27	Phase noise at 1MHz offset		-91dBc/Hz		
28	Phase noise at 4MHz offset		-103dBc/Hz		
29	Phase noise at 10MHz offset		-111dBc/Hz		

Table 11. Synthesiser Characteristics

No.	Power On Reset (POR) Specifications	Limit			Unit
		Min	Typ	Max	
30	V_{CC} POR release	0.62	0.95	1.2	Vdc
31	V_{CC} POR assert	0.45	0.65	0.85	Vdc

Table 12. Power On Reset Specifications

No.	nRESET Specifications	Limit			Unit
		Min	Typ	Max	
32	Reset Filter Time constant	2.1	12	16	µs
33	Reset Pulse width to guarantee a reset	26			µs
34	Reset Pulse width guaranteed not to cause reset	0		1	µs

Table 13. nReset Specifications

11.1 TX Power Characteristics

The diagrams below show the typical output power and module current in dependency on EM35x power setting in NORMAL MODE at 3.0V and room temperature.

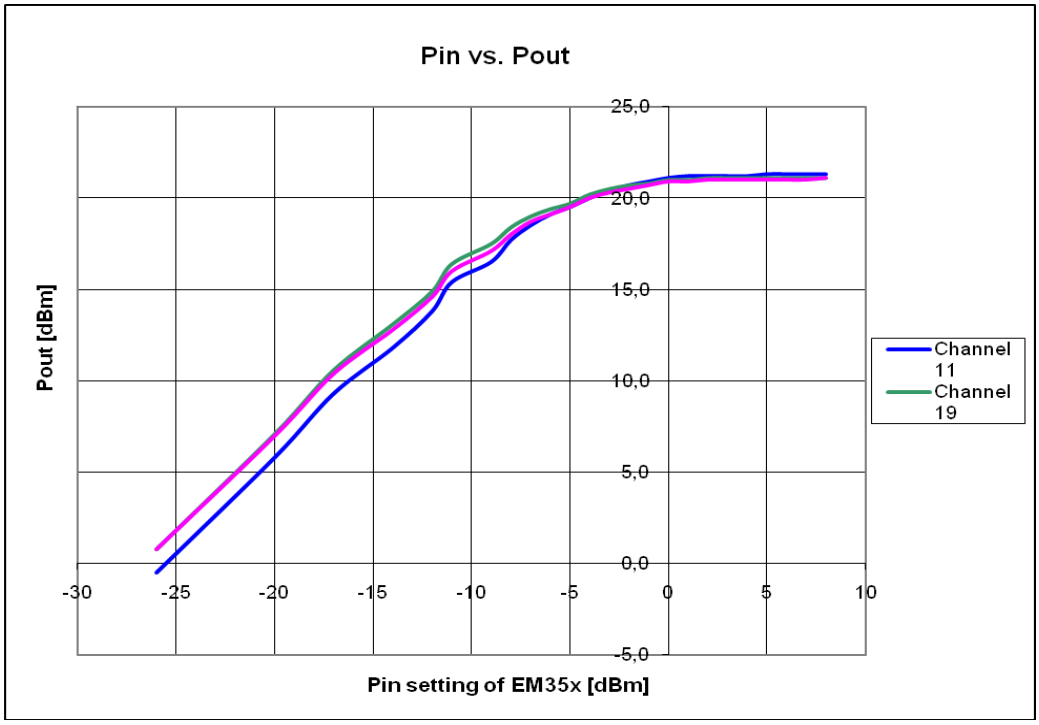


Figure 3. Output Power vs. Power Setting

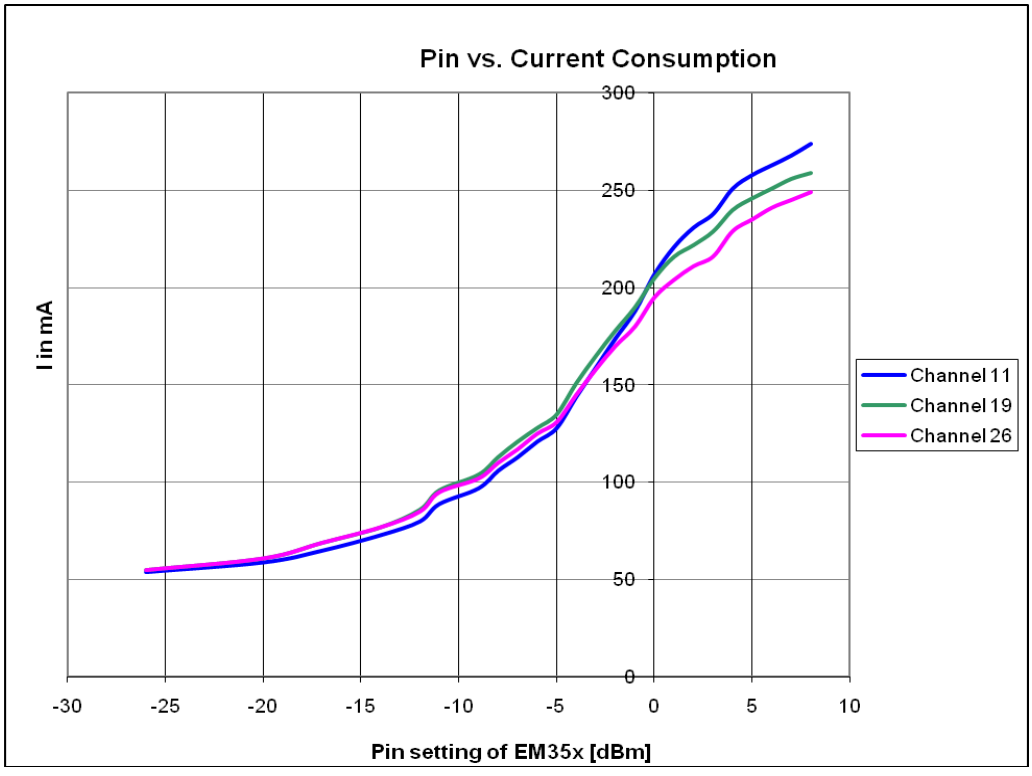


Figure 4. Module Current vs. Power Setting

11.2 Power Settings for Regulatory Compliance

Because of the high gain of the frontend module output power of up to 22dBm can be achieved When the antenna gain is included the output power of the EM35x transceivers needs to be reduced for regulatory compliance. The following tables list the maximum permitted power setting for the antenna types listed in Table 2. Note that this is the power out of the EM357 chip (set in register S01 when using Telegesis R3xx firmware), and the power delivered to the antenna will be higher by the gain of the RF power amplifier.
(V_{CC} = 3.0V, T_{AMB} = 25°C, NORMAL MODE)

Antenna	Channels 11-18	Channels 19-24	Channel 25	Channel 26
1/2 Wave	-11dBm	-11dBm	-11dBm	-11dBm
1/4 Wave	-11dBm	-11dBm	-11dBm	-11dBm
On Board	-11dBm	-11dBm	-11dBm	-11dBm

Table 14: Maximum Power Settings for European Compliance

The settings shown in Table 14 exceed the harmonized limit of 10dBm, so when using these settings the end user must notify the national authority responsible in the relevant Member State for spectrum management of the intention to place such equipment on its national market. To avoid this effort and stay below the 10dBm limit the settings shown in Table 15 (or lower) must be used.

Antenna	Channels 11-18	Channels 19-24	Channel 25	Channel 26
1/2 Wave	-17dBm	-17dBm	-17dBm	-17dBm
1/4 Wave	-17dBm	-17dBm	-17dBm	-17dBm
On Board	-17dBm	-17dBm	-17dBm	-17dBm

Table 15: Maximum Power settings for harmonized European Compliance

Finally Table 16 lists the maximum Power settings for FCC, IC and C-Tick compliance.

Antenna	Channels 11-18	Channels 19-24	Channel 25	Channel 26
1/2 Wave	-7dBm	-7dBm	-7dBm	-11dBm
1/4 Wave	-7dBm	-7dBm	-7dBm	-11dBm
On Board	-7dBm	-7dBm	-7dBm	-11dBm

Table 16: Maximum Power Settings for FCC, IC Compliance

11.3 Temperature behaviour

Figure 5and Figure 6illustrate the temperature behaviour of the ETRX35x-LRS series of modules. Please note that although the temperature behaviour was measured to up to 100 degrees Celsius the absolute maximum rating is 85 degrees Celsius.

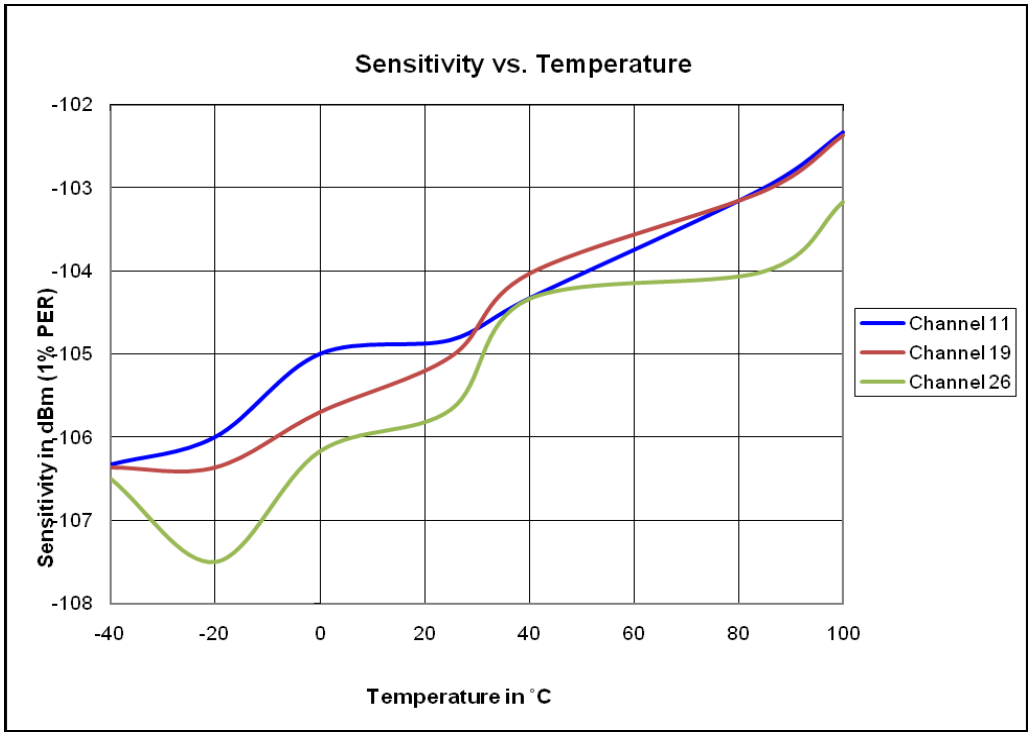


Figure 5. Sensitivity vs. Temperature

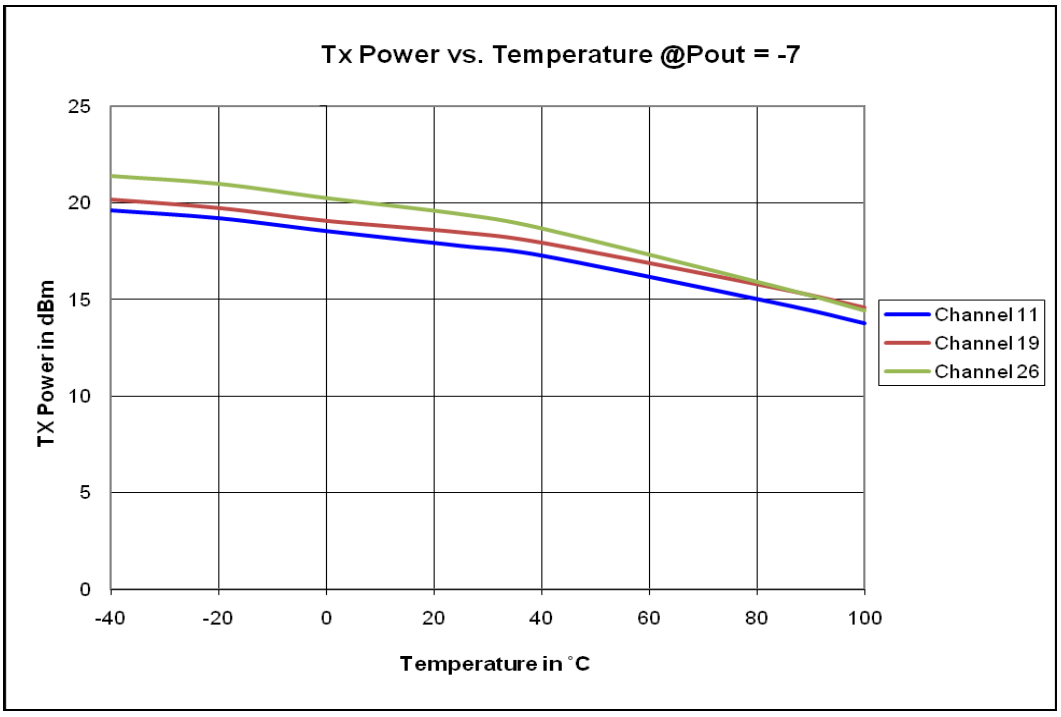


Figure 6. TX Power vs. Temperature

12 Physical Dimensions

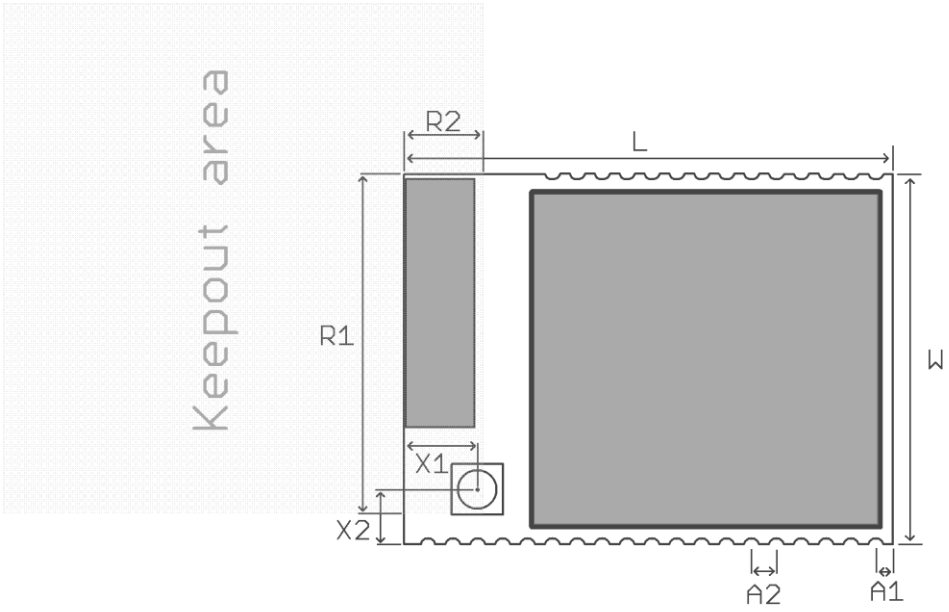


Figure 7. ETRX3 Physical Dimensions

Symbol	Explanation	Distance
L	Length of the module	25.0mm
W	Width of the module	19.0mm
H	Height of the module	3.8mm
A1	Distance centre of pad PCB edge	0.9mm
A2	Pitch	1.27mm
R1	Keep-out Zone from corner of PCB	17.5mm
R2	Keep-out Zone from corner of PCB	4.1mm
X1	Distance centre of Antenna connector PCB edge	3.8mm
X2	Distance centre of Antenna connector PCB edge	2.8mm

Table 17. ETRX3 Physical Dimensions

For ideal RF performance when using the on-board antenna, the antenna should be located at the corner of the carrier PCB. There should be no components, tracks or copper planes in the "keep-out" area which should be as large as possible. When using the U.FL RF connector the "keep-out" area does not have to be kept. **NB**: The modules' transmit/receive range will depend on the antenna used and also the housing of the finished product.

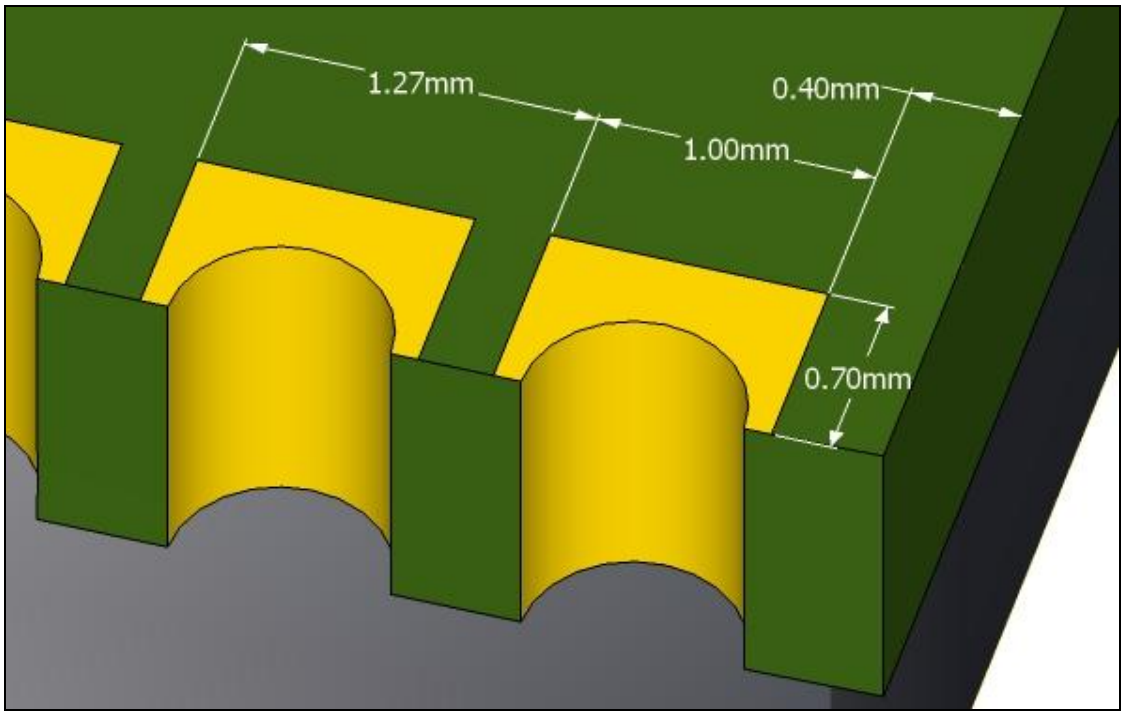


Figure 8. Typical pad dimensions

13 Soldering Temperature Time Profile (for reflow soldering)

13.1 For Leaded Solder

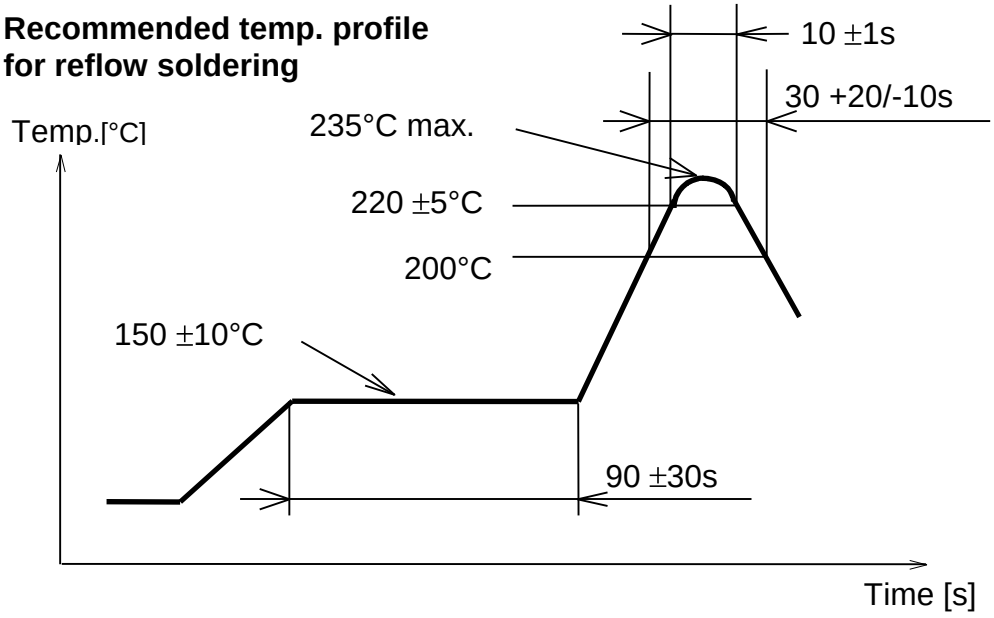


Figure 9. Temperature Profile for Lead Solder

13.2 For Lead-free Solder

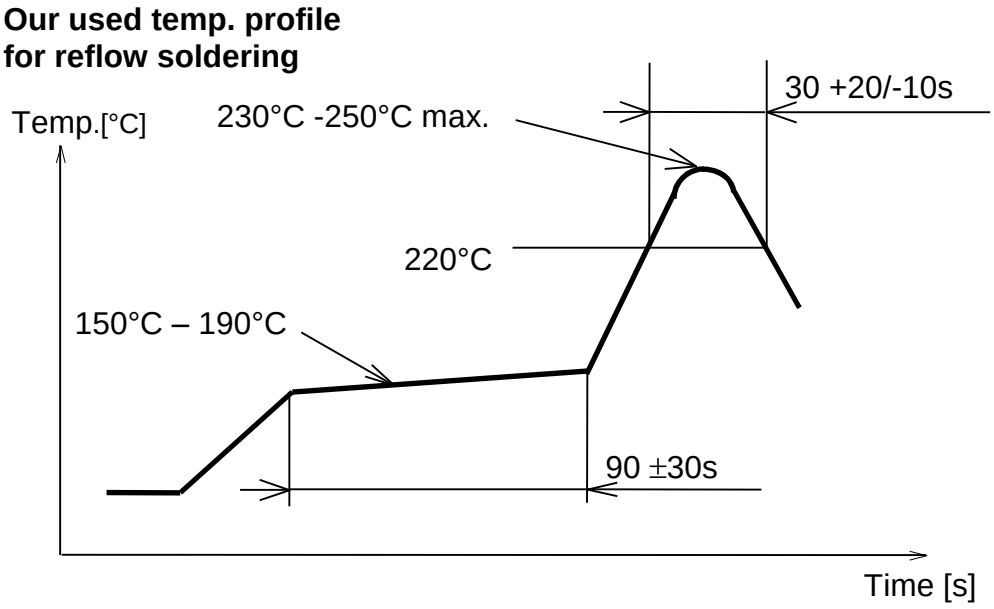


Figure 10. Temperature Profile for Lead-free Solder

NB:
Maximum Reflow Cycles: 2
Opposite-side reflow is prohibited due to the module's weight. (I.e. you must not place the module on the bottom / underside of your PCB and re-flow).

14 Product Label Drawing

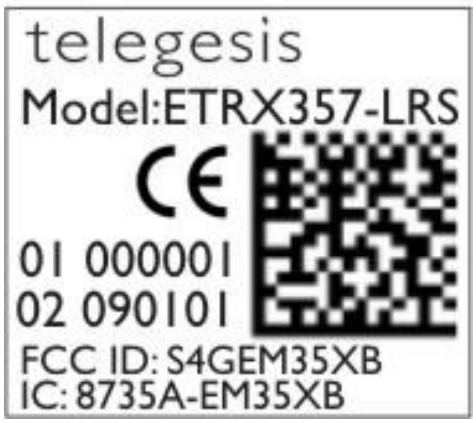


Figure 11. Product Label

The label dimensions are 16mm x 14 mm. The label will withstand temperatures used during reflow soldering. The characters “HR” are only present on the versions with the Hirose connector,

Imprint	**Description**
ETRX357HR-LR	Module Order code. Possible codes are: - ETRX357-LRS - ETRX351-LRS - ETRX357HR-LRS - ETRX351HR-LRS
000001	Indication for the serial number.
090101	Production Date Code in the format YYMMDD, e.g. 090602
01	Indication for batch number
02	Indication for the hardware revision
FCC ID: S4GEM35XB	FCC ID code for this product
IC: 8735A-EM35XB	The IC ID
CE	The CE Mark
2D-Barcode	Information in the 2D-Barcode are the serial number [6 characters], the Part-Order code [12 characters with the ‘-‘ character omitted if the product name has more than 12 characters, e.g. . “ETRX357HRLRS “ instead of “ETRX357HR-LRS”], identifier for the batch number [2 characters], the identifier for the hardware release [2 characters] and the production date code in the format Year-Month-Day [6 characters], all separated by a semicolon.

Table 18. ETRX35x-LRS Label Details

15 Recommended Footprint

In order to surface mount an ETRX3 series module, we recommend that you use pads which are 1mm wide and 1.2mm high. Unless using the “HR” variants the “keep-out” zone shown in section 12 must be retained, and it must be ensured that this area is free of copper tracks and/or copper planes/layers.

You must also ensure that there is no exposed copper on your layout which may contact with the underside of the ETRX3 series module.

For best RF performance it is required to provide good ground connections to the ground pads of the module. It is recommended to use multiple vias between each ground pad and a solid ground plane to minimize inductivity in the ground path.

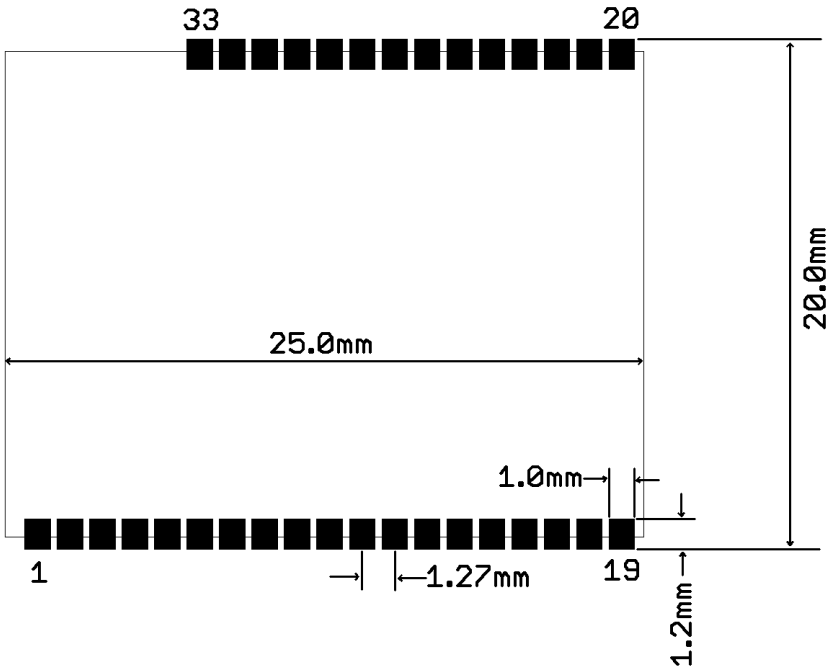


Figure 12. Recommended Footprint

The land pattern dimensions above serve as a guideline.

We recommend that you use the same pad dimensions for the solder paste screen as you have for the copper pads. However these sizes and shapes may need to be varied depending on your soldering processes and your individual production standards. We recommend a paste screen thickness of 120µm to 150µm.

Although the undersides of the ETRX3 series modules are fully coated, no exposed copper, such as through-hole vias, planes or tracks on your board component layer, should be located below the ETRX3 series module in order to avoid ‘shorts’. All ETRX3 series modules use a multilayer PCB containing an inner RF shielding ground plane, therefore there is no need to have an additional copper plane directly under the ETRX3 series module.

15.1 Example carrier board

Since the RF performance of the module with the on board antenna is strongly dependent on the proper location of the module on its carrier board, **Error! Reference source not found.**10shows the reference carrier board which was used during testing by Telegesis.

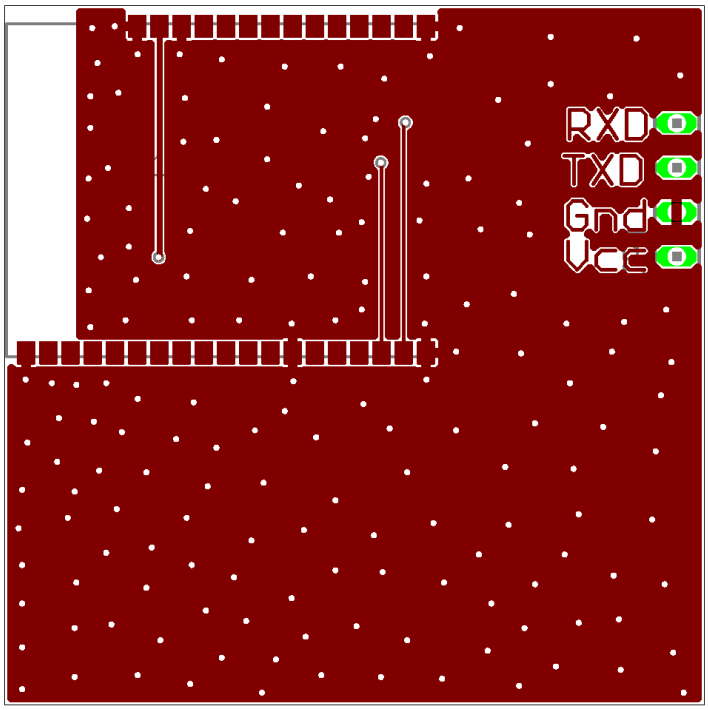


Figure 13. Reference Board

For best performance it is recommended to locate the antenna towards the corner of the carrier board and to respect the recommended keep-out areas as described in section 0.

Finally to provide a good reference ground to the on board antenna, the carrier board should have a ground plane spanning no less than 40 x 40mm. In many cases a smaller ground plane will suffice, but a degradation in radio performance could be the result.

16 Reliability Tests

The following measurements will be conducted after the module has been exposed to standard room temperature and humidity for 1 hour.

No	Item	Limit	Condition
1	Vibration test	Electrical parameter should be in specification	a) Freq.:10~50Hz,Amplitude:1.5mm a) 20min. / cycle,1hrs. each of XYZ axis b) Freq.:30~100Hz, 6G b) 20min. / cycle,1hrs. each of XYZ axis
2	Shock test	the same as the above	Dropped onto hard wood from height of 50cm for 3 times
3	Heat cycle test	the same as the above	-40°C for 30min. and +85°C for 30min.; each temperature 300 cycles
4	Moisture test	the same as the above	+60°C, 90% RH, 300h
5	Low temp. test	the same as the above	-40°C, 300h
6	High temp. test	the same as the above	+85°C, 300h

Table 19. Reliability Tests

17 Application Notes

17.1 Safety Precautions

These specifications are intended to preserve the quality assurance of products as individual components.

Before use, check and evaluate their operation when mounted on your products. Abide by these specifications when using the products. These products may short-circuit. If electrical shocks, smoke, fire, and/or accidents involving human life are anticipated when a short circuit occurs, then provide the following failsafe functions as a minimum:

(1) Ensure the safety of the whole system by installing a protection circuit and a protection device.

(2) Ensure the safety of the whole system by installing a redundant circuit or another system to prevent a single fault causing an unsafe status.

17.2 Design Engineering Notes

(1) Heat is the major cause of shortening the life of these products. Avoid assembly and use of the target equipment in conditions where the product's temperature may exceed the maximum allowable.

(2) Failure to do so may result in degrading of the product's functions and damage to the product.

(3) If pulses or other transient loads (a large load applied in a short time) are applied to the products, before use, check and evaluate their operation when assembled onto your products.

(4) These products are not intended for other uses, other than under the special conditions shown below. Before using these products under such special conditions, check their

performance and reliability under the said special conditions carefully, to determine whether or not they can be used in such a manner.

(5) In liquid, such as water, salt water, oil, alkali, or organic solvent, or in places where liquid may splash.

(6) In direct sunlight, outdoors, or in a dusty environment

(7) In an environment where condensation occurs.

(8) In an environment with a high concentration of harmful gas (e.g. salty air, HCl, Cl2, SO2, H2S, NH3, and NOx)

(9) If an abnormal voltage is applied due to a problem occurring in other components or circuits, replace these products with new products because they may not be able to provide normal performance even if their electronic characteristics and appearances appear satisfactory.

(10) Mechanical stress during assembly of the board and operation has to be avoided.

(11) Pressing on parts of the metal cover or fastening objects to the metal cover is not permitted.

17.3 Storage Conditions

(1) The module must not be stressed mechanically during storage.

(2) Do not store these products in the following conditions or the performance characteristics of the product, such as RF performance, may well be adversely affected:

(3) Storage in salty air or in an environment with a high concentration of corrosive gas, such as Cl2, H2S, NH3, SO2, or NOX

(4) Storage in direct sunlight

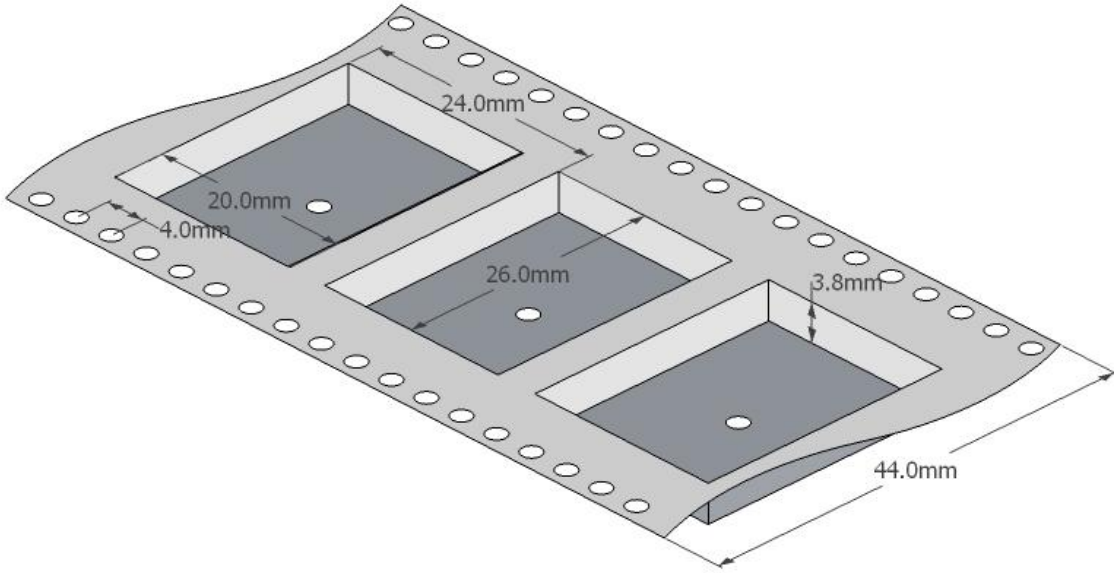
(5) Storage in an environment where the temperature may be outside the range of 5°C to 35°C range, or where the humidity may be outside the 45 to 85% range.

(6) Storage (before assembly of the end product) of the modules for more than one year after the date of delivery at your company even if all the above conditions (1) to (3) have been met, should be avoided.

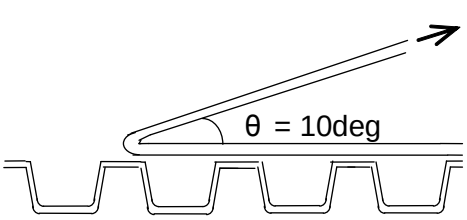
18 Packaging

18.1 Embossed Tape

(1) Dimension of the tape



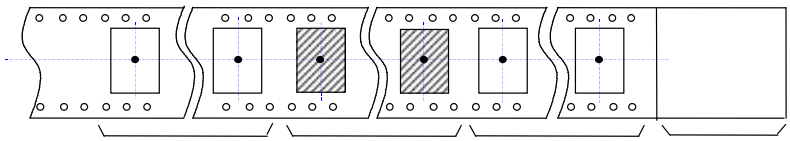
(2) Cover tape peel force



Speed = 300mm/min.

Cover tape peel force
=0.098 ~ 0.68N (10 ~ 70g)

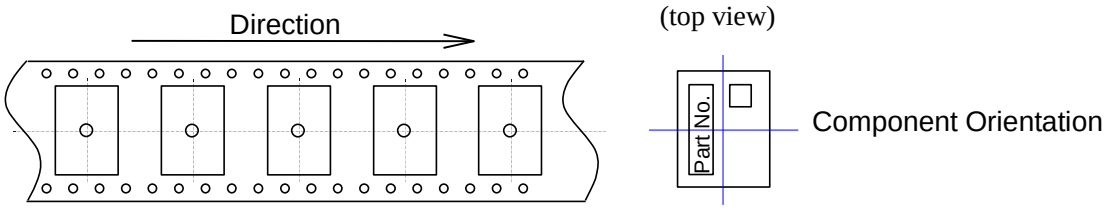
(3) Empty pockets



NB: Empty pockets in the component packed area will be less than two per reel and those empty pockets will not be consecutive.

18.2 Component Orientation

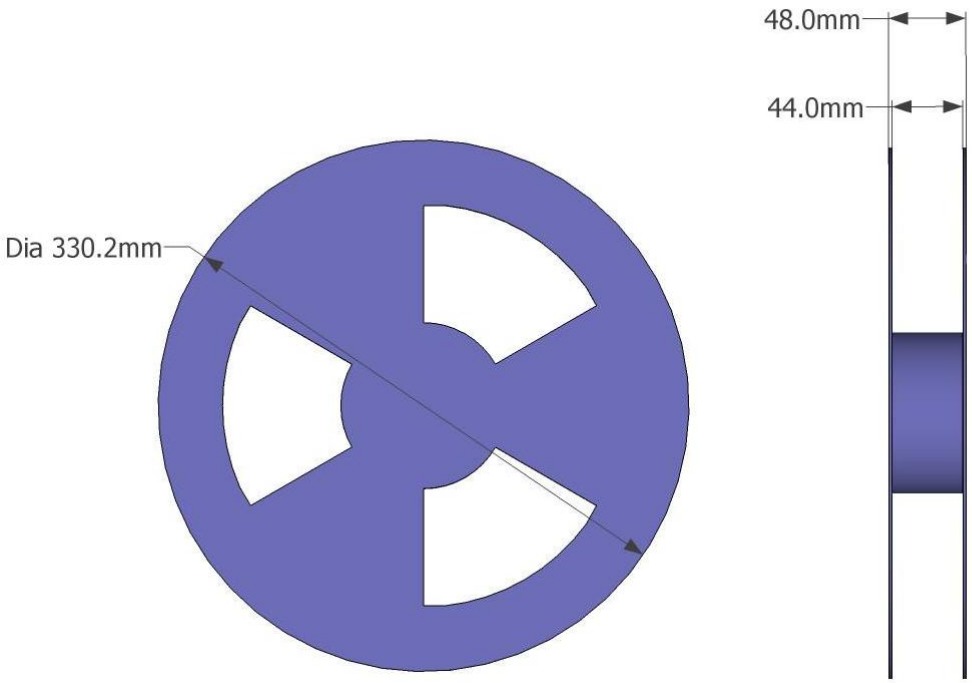
Top cover tape will not obstruct the carrier tape holes and will not extend beyond the edges of the carrier tape



18.3 Reel Dimensions

(4) Quantity per reel: 600 pieces

(5) Marking: Part No. / Quantity / Lot No. and manufacturer part# with bar-code will be on the reel



18.4 Packaging

(6) Each reel will be packed in a hermetically-sealed bag

(7) Marking : Part No. / Quantity / Lot No. and manufacturer part# with bar-code

19 Ordering Information

Ordering/Product Code	Description
ETRX351-LRS **ETRX357-LRS**	Telegesis Long Range ZigBee Module with Ember ZigBee Technology: • Based on Ember EM351 or EM357 • Telegesis AT Style Command Interpreter and • EmberZNet meshing and self-healing ZigBee PRO stack • Integrated 2.4GHz Antenna
ETRX351HR-LRS **ETRX357HR-LRS**	Telegesis Long Range ZigBee Module with Ember ZigBee Technology: • Based on Ember EM351 or EM357 • Telegesis AT Style Command Interpreter and • EmberZNet meshing and self-healing ZigBee PRO stack • U.FL Antenna Connector
ETRX3DVK	Telegesis Development Kit with: • 3 x USB Development Boards • 3 x USB Cable • 2 x ETRX35x on Carrier-Board • 2 x ETRX35xHR on Carrier-Board • 2 x ETRX35x-LRS on Carrier-Board • 2 x ETRX35xHR-LRS on Carrier-Board • 1 x ETRX3USB stick • 2 x Large Antenna • 2 x Small Stubby Antenna

Notes:

- Customers' PO's must state the Ordering/Product Code.
- There is no "blank" version of the ETRX35x-LRS modules available. All Modules are pre-programmed with the Telegesis AT style command interpreter based on the EmberZNet stack. (Where customers wish to add their own firmware they can erase and write it to the flash memory of the EM35x).

20 Trademarks

All trademarks, registered trademarks and products names are the sole property of their respective owners.

21 Disclaimer

Product and company names and logos referenced may either be trademarks or registered trademarks of their respective companies. We reserve the right to make modifications and/or improvements without prior notification. All information is correct at time of issue. Telegesis (UK) Ltd does not convey any license under its patent rights or assume any responsibility for the use of the described product

22 RoHS Declaration

Declaration of environmental compatibility for supplied products:

Hereby we declare to our best present knowledge based on the declaration of our suppliers that this product does not contain the following substances which are banned by Directive 2002/95/EC (RoHS) or if they do, contain a maximum concentration of 0,1% by weight in homogeneous materials for:

- Lead and lead compounds
- Mercury and mercury compounds
- Chromium (VI)
- PBB (polybrominated biphenyl) category
- PBDE (polybrominated biphenyl ether) category

And a maximum concentration of 0.01% by weight in homogeneous materials for:

- Cadmium and cadmium compounds

23 Data Sheet Status

Telegesis (UK) Ltd. reserves the right to change the specification without notice, in order to improve the design and supply the best possible product. Please consult the most recently issued data sheet before initiating or completing a design.

24 Life Support Policy

This product is not designed for use in life support appliances, devices, or systems where malfunction can reasonably be expected to result in a significant personal injury to the user, or as a critical component in any life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness. Customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Telegesis (UK) Ltd. for any damages resulting.

25 Related Documents

[1] IEEE Standard 802.15.4 –2003 Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (LR-WPANs)

[2] Datasheet EM35x, Ember. (www.ember.com)

[3] Datasheet U.FL-Series 2004.2 Hirose Ultra Small Surface Mount Coaxial Connectors - Low Profile 1.9mm or 2.4mm Mated Height

[4] The ZigBee specification (www.zigbee.org)

[5] Specification for Antenova Rufa Antenna (www.antenova.com)

26 Contact Information

Website: www.telegesis.com
E-mail sales@telegesis.com

Telegesis (UK) Limited
Abbey Barn Business Centre
Abbey Barn Lane
High Wycombe
Bucks
HP10 9QQ
UK

Tel: +44 (0)1494 510199

Fax: +44 (0)5603 436999